



National Aeronautics and
Space Administration



Medical Data Architecture Capabilities and Design

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Overview

- Project Background
- Objectives/Challenges
- System Overview
- Integrated Devices
- Current Status/Next Steps



Project Background

ExMC Element Risk

Risk of Adverse Health Outcomes & Decrements in Performance due to Inflight Medical Conditions

MDA Need

ExMC Gap Med07: We do not have the capability to comprehensively process medical-relevant information to support medical operations during exploration missions.

MDA Goal

The MDA project will develop capabilities that support autonomous data collection, and necessary functionality and challenges in executing a self-contained medical system that approaches crew health care delivery without assistance from ground support.



MDA Project Objectives

- Develop a system to comprehensively manage and process medically-relevant information to support medical operations during exploration missions
- Build a series of test beds that incrementally add capability
- The system will provide the data architecture foundation to:
 - Facilitate autonomous data collection
 - Promote seamless communication with medical and non-medical devices
 - Accommodate data streams in varying formats
 - Provide data management capability for medical operations



Challenges

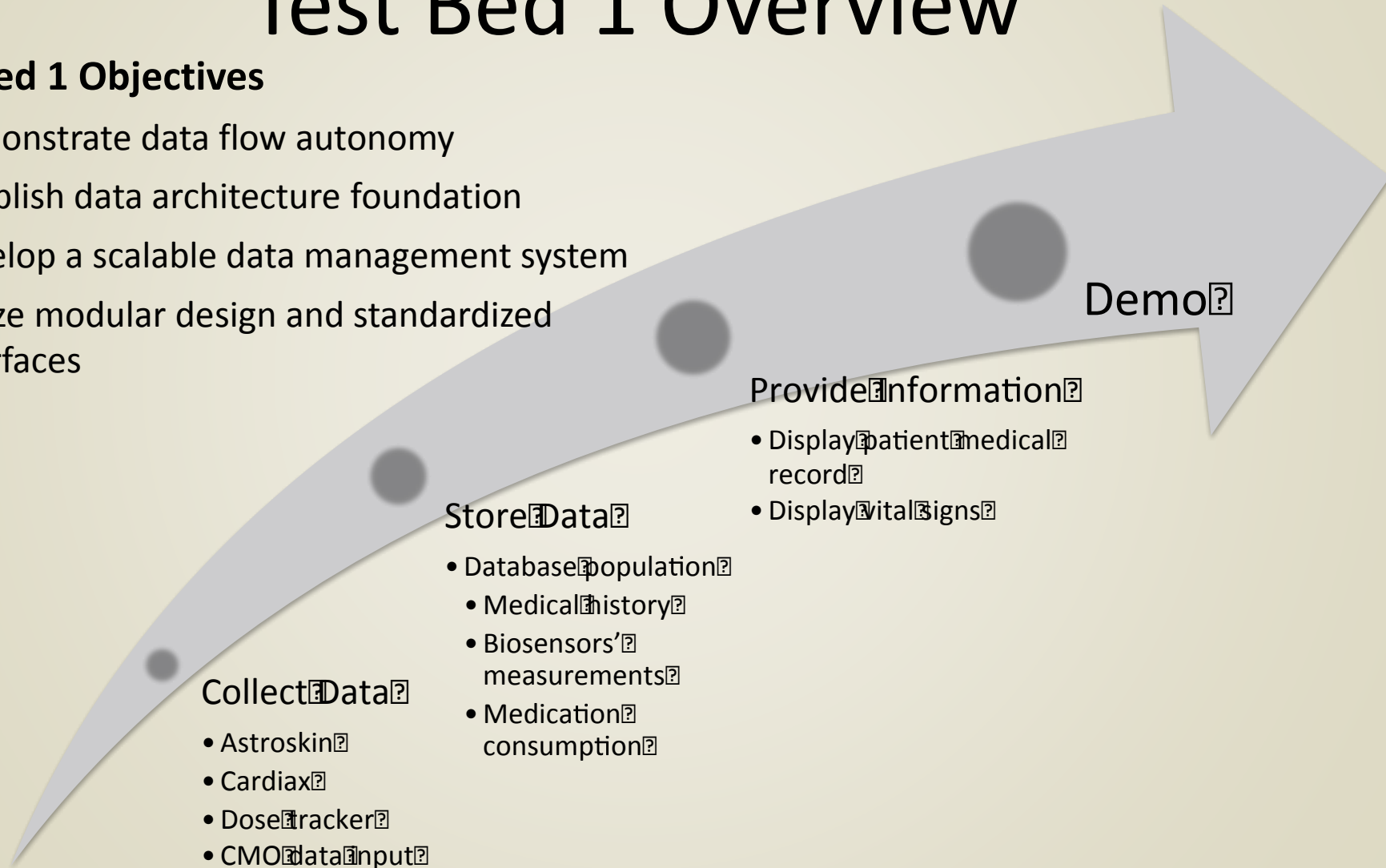
- Implement NASA Space Flight Human-System Standard NASA-STD-3001
 - Level of Care V: “A high level of potential risk exists that personnel may experience medical problems on orbit at some time during the mission.”
 - Increasing levels of autonomous care
- Limited Resources
 - Medical knowledge and skills (Integrated data/knowledge management)
 - Supplies and equipment
 - No resupply
- Autonomous Crew Medical Operations
 - Delayed communications
 - No ability for medical evacuation
- Accommodate future technologies



Test Bed 1 Overview

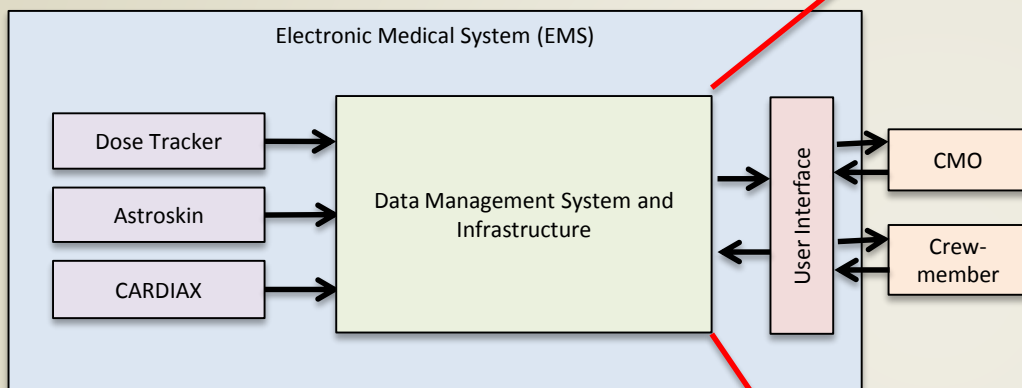
Test Bed 1 Objectives

- Demonstrate data flow autonomy
- Establish data architecture foundation
- Develop a scalable data management system
- Utilize modular design and standardized interfaces





MDA Test Bed 1 Functional Block Diagram



- Modular design
 - Layers allow for organization of code and components
 - Biosensor device adapters are modular
- Subsystems separated by interfaces
 - Drop-in replacements of systems in later versions (upgrades, etc)

User Equipment Layer



User Interface Layer



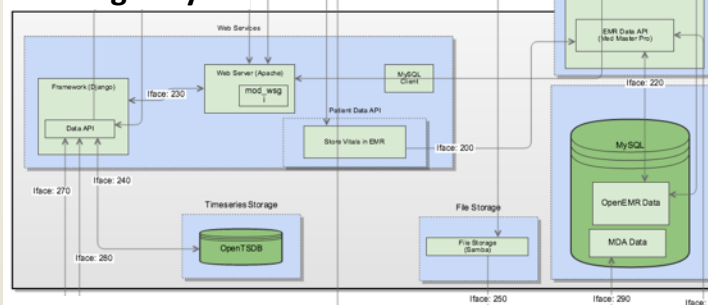
Discovery and Analytics Layer



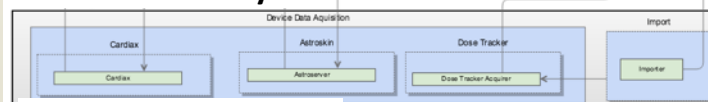
Analytical Layer



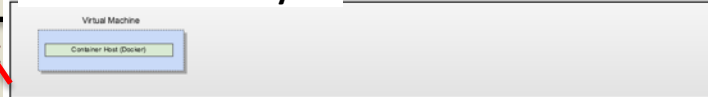
Storage Layer



Data Sources Layer



Infrastructure Layer





Software Layers

• User Equipment Layer

- Standard web browser (Laptop/Tablet) - **Complete**
- ECG monitor (CARDIAX) - **Complete**
- Wearable biosensor vest for vital signs (Astroskin) - **Complete**
- iPad application currently onboard ISS (Dose Tracker) - **Future Work**

• User Interface Layer

- Electronic Medical Records (OpenEMR) - **In Progress**
- Search and display of biosensor data - **In Progress**

• Analytical Layer

- Data reduction: reduce streams of heart beat events to a single number - **In Progress**

User Equipment Layer



User Interface Layer



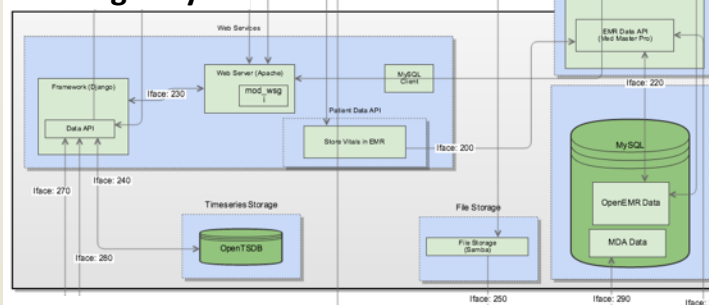
Discovery and Analytics Layer



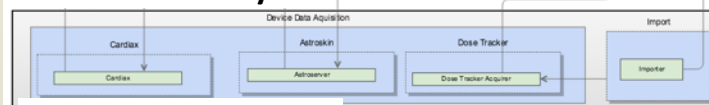
Analytical Layer



Storage Layer



Data Sources Layer



Infrastructure Layer

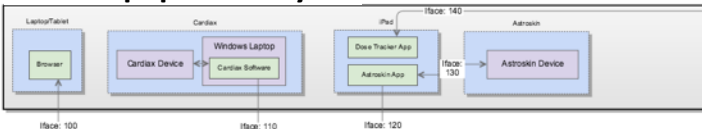




Software Layers

- **Storage Layer**
 - Data API - **Complete**
 - Stores/retrieves biosensor data
 - Backed by relational and time series databases (MySQL, OpenTSDB, HBASE)
- **Data Sources Layer**
 - Software supporting
 - CARDIAX - **In Progress**
 - Astroskin - **Complete**
 - Dose Tracker - **1.1 Release**
 - Crew Data Importer - **In Progress**
- **Infrastructure Layer**
 - Server(s) - **Complete**
- **Discovery and Analytics Layer**
 - No components in Test Bed 1

User Equipment Layer



User Interface Layer



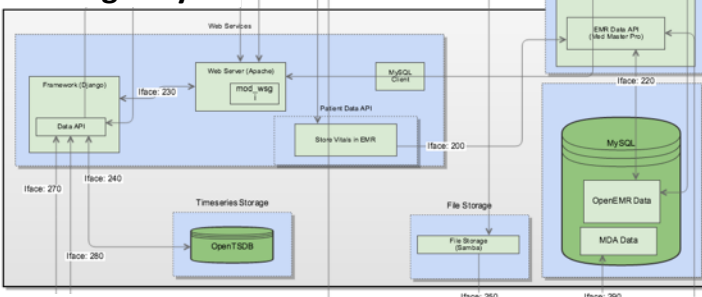
Discovery and Analytics Layer



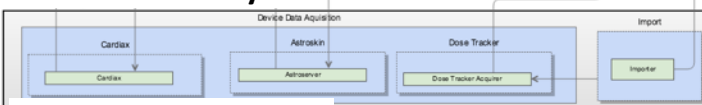
Analytical Layer



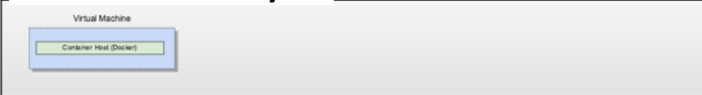
Storage Layer



Data Sources Layer



Infrastructure Layer





System Overview

- Integrates biomedical devices with medical records system
 - “Vitals” and ECG data are automatically populated into EMR
- Software deployment options for development, laboratory and analog testing
 - Hardware (stand-alone servers, “cloud” systems, laptops)
 - Operating System (UNIX, Mac, Windows)
- Automated software build
 - Pre-configures with a standard load of patient data
 - Reduces manual data entry
- Uses open-source components
- NASA Class C software and process

Medical Records System

- Lightly modified open source Electronic Medical Records system “OpenEMR”
 - Integration with biosensor data for auto-populating and plotting data
 - Remove links to insurance billing

NEW PATIENT

Hide Menu

Patient: **Jared Smith (1)**
DOB: 1961-11-26 Age: 55

Encounter History
Selected Encounter: 2016-12-01 (202)

Default

Top

Bot

Messages (25)

Patient/Client

Patients

New/Search

Summary

Visits

Create Visit

Current

Visit History

Records

Visit Forms

Procedures

Administration

Reports

Miscellaneous

Popups

Find:

Name

ID

SSN

DOB

Any

Filter

Online Support

Smith, Jared

Delete

Reset Onsite Portal Credentials

History

Report

Documents

Transactions

Issues

Edit

Demographics (collapse)

Who

Contact

Choices

Employer

Stats

Misc

Name:

Dr. Jared A Smith

DOB:

1961-11-26

S.S.:

351389233

External ID:

1

Sex:

Male

License/ID:

Marital Status:

Married

User Defined:

Jerry Smith

Edit

Delete

SOAP by Administrator (Collapse)

Subjective:

Sub: Patient experiencing some pain and discomforting in anterior region of right shoulder. Occur when using HULK for daily exercise routine. First occurrence was three days prior. Patient describes as a low level of pain that can be felt with increased movement.

Objective:

Obj: Patient's vitals are all within normal, healthy limits. Based on assessment, no major issues found. Likely a mild case of bursitis.

Assessment:

Ass: Palpation of anterior region shows mild tenderness, but range of motion, strength, and stability are not affected.

Plan:

Plan: 440mg of Naproxen for pain and inflammation twice a day for five days. Reduce level of efforts during exercise. Evaluate exercise routine. Follow up after five days.

Edit

Delete

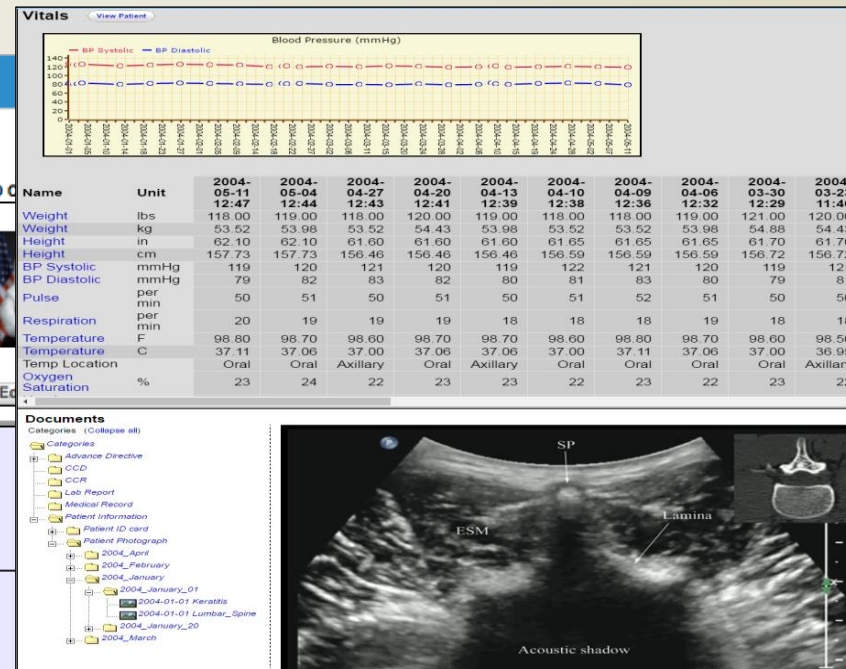
Patient Encounter by Administrator (Collapse)

Reason:

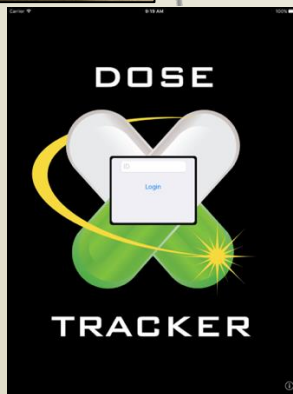
Scheduled private medical conference. Patient has recently completed daily exercise routine. Patient is experiencing low level shoulder pain after using HULK during exercise routine. No other complaints or concerns.

Facility:

Prometheus Service



Ultrasound of lumbar spine



Devices

Astroskin

- Wearable garment-based monitoring system
- Sensors: Accelerometers, 3-lead ECG, respiration, SpO₂, Systolic Blood pressure, skin temperature

CARDIAX

- Wireless, 12-Lead ECG
- ECG Glove: Built-In lead wires attached to pre-positioned electrodes

Dose Tracker

- Collects ISS crewmember medication
 - Usage, dosage, frequency
 - Side effects



Current Status

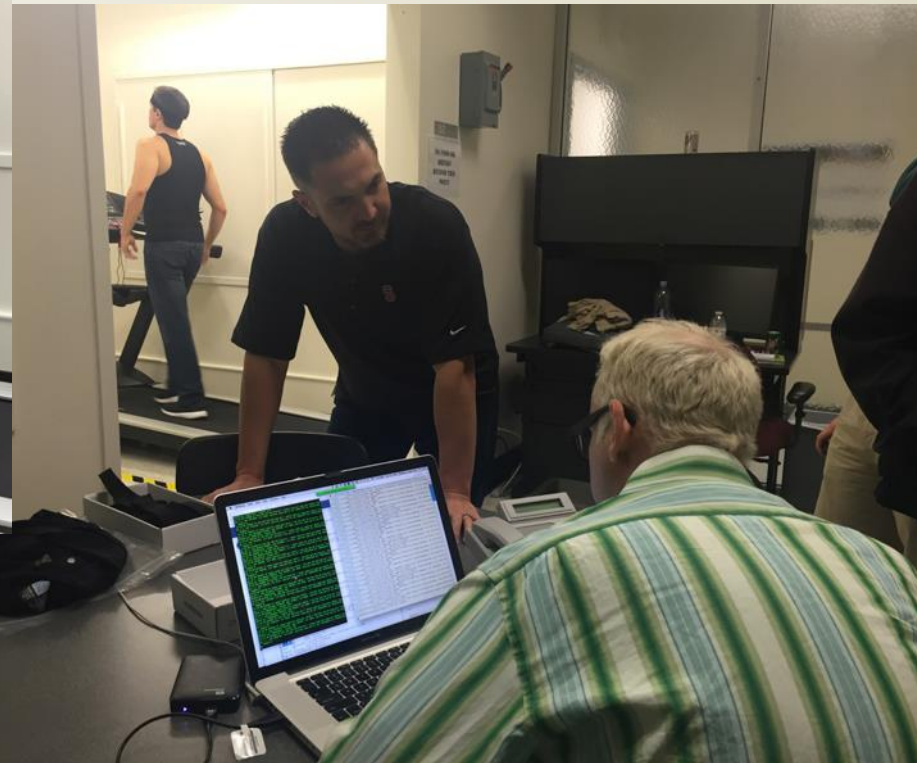
- Passed gate reviews
 - System Requirements Review (SRR)
 - Preliminary Design Review (PDR) / Critical Design Review (CDR)
 - From the final PDR/CDR board report:
 - “As detailed in the 'Review Success Criteria Assessment' section of this report, the project has met, as ‘successful’, all ToR-defined review success criteria.”
 - “ExMC MDA continues to employ a robust incremental phased approach to the Test Beds 1-4, and has documented its technical architecture and allocation of requirements, developed in conjunction with customer’s requirements.”
 - Currently in implementation phase



Test Bed 1 in the Lab



ExMC staff execute demonstration at ARC



ExMC staff execute demonstration at ARC



Next Steps

- Scoping potential “Test Bed 1.5” (not baselined)
 - Operate in cooperation with habitat evaluations
 - Integrate exercise device(s)
 - Provide biosensor “telemetry” to spacecraft simulators
- Test Bed 1 Demo – April 2017
- Test Bed 1.0 Release – June 2017
 - Patch Release 1.1 – August 2017 (with Dose Tracker)
- Test Bed 2.0 Scope Completion – July 2017
- Test Bed 2.0 SRR – August 2017